

coverage can be achieved by installing one transmitter with ten voice channels at each base station site in the specified area.^{56/}

While this deterministic model largely holds true for many isolated parts of a service area, it will clearly not be correct even across a metropolitan area. It is obvious that PCS users will not always be uniformly distributed, because there will be areas where there will be very high user concentrations. These “hot spots” will be non-uniformly distributed within a service area. Typical examples are shopping malls, stadiums, transportation centers, and educational institutions. In such areas, more than one transceiver per cell site may be needed. A 20 MHz allocation would not allow more than one transceiver. It is noteworthy that the advocates of a smaller allocation than 25 MHz do not address the issue of unevenly distributed usage.^{57/}

Additional spectrum will also be required because of the need to provide sufficient capacity not only for usage by local residents but also for roamer usage. Public PCS base stations will provide access not only to subscribers living or working in the

^{55/}(...continued)

assumed that “all cells throughout the PCS network are . . . the same size, and enough cells are deployed to provide coverage over the entire area.” *Id.* at 7.

^{56/} See generally D.C. Cox, *A Radio System Proposal for Widespread Low-Power Tetherless Communications*, 39 IEEE TRANS. ON COMMS. No. 2 (Feb. 1991), cited in U S WEST Comments at 5 n.4.

^{57/} For example, the OPP’s analysis of the spectrum requirements for PCS is based entirely on the even distribution of homes in a new suburban subdivision and ignores entirely the higher demands that will be placed on base stations in a dense urban residential environment or central business district, even with very closely-spaced base stations, or the even-greater demands that will be placed on microcells in shopping malls, airports, or stadiums. See OPP Paper at 5-7. By focusing on PCS almost exclusively as a substitute for residential wireline telephones, the OPP Paper loses sight of the fact that a key advantage of PCS is *mobility* — PCS handsets will be used in a wide variety of environments even by the residents of OPP’s hypothetical suburban subdivision, as users take their phones with them as they work, travel, shop, and attend special events.

immediate area but also to users who are temporarily near any given base station. This will have a negative effect on the capacity available for subscribers who are expected to use a given base station because of their nearby offices or residences. For example, some of the evenly spaced base stations in a hypothetical suburban community will be more heavily loaded than others because of their proximity to local stores, community centers, or thoroughfares. If additional capacity is not made available to handle the additional load on such facilities, as well as the extraordinary load placed on base stations in and around the hot spots at times of peak traffic, quality of service will decline — and decline dramatically.^{58/}

Bellcore has estimated that up to 60 MHz of spectrum is required to support tripling the number of channels per base station to thirty in order to accommodate high usage levels. Because of the random distribution of hot spots, however, additional capacity will not be needed at all locations. Accordingly, a more moderate additional spectrum allocation than that suggested by Bellcore will allow PCS system designers to provide additional capacity where it is most needed. Although quality may suffer somewhat in the most extreme cases even with additional spectrum (such as 25 MHz),^{59/} careful engineering and dynamic channel allocations would alleviate most problems. Accordingly, U S WEST urges an allocation of at least 25 MHz (*i.e.*, an additional 5 MHz over the 20 MHz base model) so as to assure both sufficient capacity and acceptable quality in peak traffic areas.

^{58/} This phenomenon currently plagues many cellular systems. Even with relatively small cells covering congested highways, stadiums, or high-usage business districts, quality of service — both for the roamers and for the local subscribers in these cells — can become unacceptable due to blocking during periods of peak usage.

^{59/} It would be reasonable to assume that users would tolerate some lowering of the probability of coverage in such areas at times of peak demand. Moreover, it might be too costly, in terms of both spectrum and facilities, to provide sufficient capacity for 0.99 probability of coverage during half-time in a football stadium or the peak of holiday shopping in a mall.

C. Spectrum Blocks of at Least 25 MHz Will Be Needed to Meet Increasing Needs for Data, Facsimile, and Other Innovative Services

Data and facsimile transmissions are a rapidly increasing use of wireline local exchange and cellular facilities, and it is expected that PCS customers will have similar non-voice communications requirements. If PCS systems are to be a reasonable complement to, or replacement for, wireline and cellular telephone usage, PCS systems must have the ability to meet customers' needs for wireless data and facsimile services.

Some of the need for these services can be accommodated by one-way or two-way messaging services such as paging systems, mobile data networks, cellular systems enhanced to provide data transmission services, mobile satellite service, and narrowband PCS. However, many users will want to connect computers, facsimile machines, or imaging devices to their PCS handsets in the same way they can use the wireline telephone network. Moreover, there are additional future demands that will be placed on cellular, private radio, and PCS networks by Intelligent Vehicle Highway Systems, wireless ISDN, video imaging,^{60/} and other innovative services. It is illogical to assume, as do some commenters, that a 20 MHz allocation will provide adequate capacity for a PCS licensee to provide "digital microcellular voice, mobile facsimile, high speed data, or even portable video applications."^{61/} In fact, these non-voice uses of PCS may demand significantly more

^{60/} British Telecom recently demonstrated the transmission of full-motion video over a DECT cordless telephone system using a channel bit rate of 128 kb/s and a H.261 compliant codec. *DECT-Standard Demo Puts Full-Motion Video over Cordless Link*, ELECTRONIC DESIGN (September 17, 1992).

^{61/} McCaw Comments at 8.

spectrum than voice services, particularly if the technology used for PCS is optimized for highly efficient voice transmission.^{62/}

Data services will create a rapidly growing demand for additional transmission bandwidth, processing speed, and storage capacity. It is a cyclical phenomenon where an increase in one performance parameter (*e.g.*, processor speed) creates a demand for the improvement of other parameters (*e.g.*, transmission rates). In the last decade, we have seen mass market computing devices exhibiting these characteristics. Modems have increased in speed from 300 b/s to 14,400 b/s, microprocessor clock rates have risen from 4.77 MHz to 50 MHz, storage media capacities have grown from 10 MB to over 200 MB, and LAN speeds have increased from 1.5-2 MB/s to 100 MB/s. The demands that will be placed on PCS for data transmission can be expected to grow in a similar fashion. It is therefore logical to increase the size of the PCS allocations to accommodate the *potential* for growth in wireless data services, instead of relegating the increasing demand for wireless data service capacity to a further rulemaking in four or five years, when the market begins growing at a geometric rate. If PCS is to become the family of services envisioned by the Commission, licensees must have adequate spectrum to support not only the data, graphics, and facsimile transmission requirements that typify today's wireline telephone network usage (and are inevitable at the outset of PCS), but also those that are likely to evolve as the result of making wireless data access available to the mass market in the foreseeable future.

^{62/} For example, Code Division Multiple Access ("CDMA") can yield a fifteen-fold increase in capacity over analog transmission for voice transmissions, but its efficiency advantage over analog diminishes when data is transmitted because of the need for error correction. See Letter from John E. DeFeo, President and Chief Executive Officer of U S WEST NewVector Group, Inc., to Commissioner Andrew C. Barrett, dated January 15, 1992, at 2-3, a copy of which was filed in Gen. Docket 90-314. Moreover, encoding techniques that take advantage of the nature of speech patterns to achieve high efficiency through compression are inefficient when a user transmits modem data or facsimile over the same communications circuit.

D. Larger Blocks of Spectrum Will Lessen the Impact of Co-Channel Microwave on PCS and the Need for Relocation of Microwave

Numerous comments make clear that some degree of spectrum sharing between PCS and fixed microwave systems will be feasible in many instances through a variety of techniques.^{63/} Nevertheless, these techniques do not permit unfettered PCS use of spectrum at all locations. Rather, they facilitate the PCS system's avoidance of channels whose use would cause interference to fixed services. These techniques also minimize the power level of PCS transmissions in certain areas and on certain channels in order to avoid interfering with microwave transmissions.^{64/}

Application of these techniques will not ensure that a PCS system will have access to the amount of spectrum needed to accommodate the system's traffic level at any and all locations in a service area as calls are originated or terminated. They do ensure that PCS will not interfere with fixed services, but they do not ensure that PCS will have sufficient spectrum available. It is for this very reason that one of the principal proponents of a microwave sharing technique has advocated a PCS spectrum allocation of 40 MHz per licensee:

[T]here are some areas in some markets where incumbents occupy virtually all available spectrum. The smaller the allocation given to each PCS licensee, the greater the number of areas that would have no spectrum available. If allocations are too small, it would be impossible to initiate service without immediately relocating incumbent users because PCS licensees would be denied the flexibility to work around these users.^{65/}

^{63/} See, SWB Comments at 28-31.

^{64/} See *id.*

^{65/} APC Comments at 10.

The existence of microwave transmission paths will, under any technique, have a significant effect on a PCS system's ability to carry traffic in those areas where PCS transmissions on particular channels would cause interference to microwave reception at any particular time. In some markets, fixed microwave use may entirely preclude the establishment of PCS service unless the fixed users are relocated.^{66/}

In this connection, it is important to recognize that the Commission plans to exempt public safety licensees from involuntary relocation; one cannot, therefore, assume that a PCS licensee will be able to clear out incompatible fixed uses from its spectrum block, even after a transition period.^{67/} OPP, which concludes that 20 MHz of clear spectrum should be sufficient for each PCS licensee, wisely acknowledges that the incumbency of fixed microwave users will have the effect of justifying a greater allocation per licensee:

While this study has assumed that all the spectrum in the allocation is available to the licensee, in reality PCS applications will have to coexist with existing fixed point-to-point microwave users in the 2 GHz band. . . . In short, while the model results show that the benefits of additional spectrum above 20 MHz of

^{66/} For example, one commenter demonstrated that in the New York area, 20 MHz PCS licensees would not be able to find any spectrum available for PCS use throughout 20-40% of the area, while 40 MHz licensees would find spectrum unavailable in only about 12% of the area. Significantly, the only areas with relatively unimpaired spectrum availability are the outermost suburbs of New Jersey and Westchester; if a 20 MHz allocation were used, no spectrum would be available for PCS in the most populous parts of the area. On the other hand, APC showed that if the three microwave paths most responsible for this blockage were relocated to a different frequency band, PCS licensees would have spectrum available in nearly the entire area, with only about 2-3% of the area having no spectrum available for PCS if there were two 40 MHz licensees, and with about 2-14% of the area precluded if there were five 20 MHz licensees. *See id.* at Attachment A.

^{67/} While PCS licensees will be permitted to negotiate with fixed licensees (including public safety licensees) for voluntary relocation, *see, e.g.,* McCaw Comments at 9 n.16, there is no assurance that the incumbent licensees will be willing to negotiate. Under these circumstances, a PCS licensee may not in some cases have access to *any* spectrum in many portions of its service area. Thus, there is no basis on which to assume that "new PCS carriers will be able to engage in incremental relocation of existing users." *See id.*

clear spectrum are minimal, the increased interference requirements due to incumbent microwave users could be a reason for a larger spectrum allocation size, particularly in regions of dense microwave use.^{68/}

U S WEST is concerned that fixed services will be a greater obstacle to PCS spectrum usage than has been appreciated to date, and urges a minimum allocation of 25 MHz to mitigate the effect of incumbent microwave usage. OPP succinctly summarized this viewpoint when it said, "there could be concern . . . that the 20 MHz licenses may not be sufficiently large to allow suppliers to implement low-cost radio systems in areas where high densities of microwave users exist."^{69/} This is a very real concern. It is for this reason that U S WEST submits that a 20 MHz block will simply not be sufficient for PCS that is co-primary to fixed microwave service.

E. Smaller Spectrum Blocks Would Result in Less-Capable Licensees and Less Diversity of Services

For all of the reasons discussed above, a relatively small block of spectrum for each licensee (*i.e.*, less than 25 MHz) will place significant limits on licensees' ability to provide quality PCS voice services and will greatly restrict their ability to accommodate new services, such as data and facsimile. Indeed, a PCS licensee who must coexist with existing fixed microwave users may be unable to offer any service in critical areas, much less quality service or non-voice services. It is clear that a licensee with unfettered access to only a portion of its block of spectrum will be restricted significantly in capacity, quality, and variety of services. Licensees with barely sufficient spectrum to maintain low-quality, voice-only service in areas where there is a constant demand for service will not be in a position to offer a diverse range of new and innovative services.

^{68/} OPP Paper at 53-54.

^{69/} *Id.* at 55.

In some cases, the problem posed by microwave licensees may be mitigated by relocating them. Even so, a PCS network with only 20 MHz of clear spectrum will face limitations on the quality, capacity, and variety of services that can be offered. If each licensee initially receives only 20 MHz of spectrum, some licensees may find it necessary to acquire additional spectrum from other licensees in order to provide needed services in all or part of their service areas (assuming the Commission permits such acquisitions).^{70/} Licensees receiving a larger initial allocation will naturally have access to a greater quantity of usable spectrum and will find it less necessary to acquire additional spectrum from others. Thus, by initially allocating only 20 MHz per licensee, the Commission would essentially be leaving the number and size of licensees to be determined through a series of highly inefficient transactions. The need for these transactions can be minimized by initially allocating a sufficiently large block of spectrum to each licensee at the outset.

F. Four 25 MHz Licensees Is an Appropriate Compromise Between Competition (Number of Providers), Diversity of Services (Enabled by Substantial Spectrum Blocks), and Efficient Spectrum Utilization with the Least Impact on Microwave Use

PCS operators need sufficient spectrum to provide a wide variety of low-cost services that will enable customers to communicate on the move. Low cost and diversity militate in favor of large blocks of spectrum. At the same time, the Commission seeks to encourage competitive delivery of services, which means that the available spectrum must be divided among multiple licensees, limiting the amount of spectrum that each can use. Finding the proper balance is a difficult task indeed.

^{70/} OPP has proposed that licensees be permitted to acquire spectrum from other PCS licensees, up to a maximum of 40 MHz. *See id.* at 55.

U S WEST urges the Commission to authorize the largest blocks of spectrum that are compatible with a competitive environment. There clearly must be more than two licensees if there is to be real and meaningful competition. The minimum spectrum block that could be used to provide cost-effective, high-quality PCS portable voice telephone service, in a relatively evenly distributed user environment, appears to be in the area of 20 MHz. This requirement must be scaled upward in light of the need to accommodate non-voice services, the need to share spectrum with fixed microwave licensees, and the need to provide high quality service not only throughout low-density, evenly distributed, suburban residential communities but also in high-density urban neighborhoods, business districts, and areas of high peak usage.

For all these reasons, each licensee should have access to no less than 25 MHz, and more if possible. This would permit the Commission to license four service providers, which would provide a highly competitive environment for the delivery of PCS. ^{11/} At the same time, it would make 40 MHz available for unlicensed "User-PCS." The use of 25 MHz or larger blocks for PCS licensing will lessen the need for microwave relocation, because a licensee will more than likely be able to find useable spectrum within a larger allocation than it would find in a 20 MHz block. Accordingly, U S WEST strongly urges the Commission to award blocks of spectrum no smaller than 25 MHz for the provision of licensed PCS services.

^{11/} As explained in its December 1-2, 1992 *Ex Parte* filing in this proceeding and its November 9, 1992 Comments, U S WEST has done extensive financial analysis and modeling for the potential PCS market. The model is based upon the research of U S WEST and others which indicates that total market demand for wireless public voice mobility services (both existing cellular and new PCS) ranges from 21 to 37%. U S WEST has concluded that a minimum of 11 to 14% total market saturation penetration for new PCS services must be achieved for four PCS licensees to be viable. This level of PCS market saturation is not certain. Therefore, in addition to limited availability of spectrum, the financial modeling done by U S WEST for PCS services indicates that no more than four licenses should be awarded.

IV. THE COMMISSION SHOULD ALLOCATE 40 MHZ FOR UNLICENSED "USER-PCS"

The proponents of a substantial allocation for unlicensed "User-PCS" have made a persuasive case for an allocation of 40 MHz, rather than 20 MHz, for unlicensed use.^{72/} On reviewing these comments, U S WEST fully supports the allocation of 40 MHz for unlicensed "User-PCS." U S WEST has been evaluating the use of unlicensed spectrum for indoor and outdoor voice and data applications for several years.^{73/} The increasing power of laptop and palmtop computing devices, the proliferation of local area networks, and the rapid development of wireless mobile data services, taken together, suggest that there will be a very substantial user base for unlicensed, low cost wireless data transmission products such as local area network nodes. Moreover, demand for other wireless devices, such as cordless telephones and remote controls, has grown tremendously in recent years. The success of such wireless devices suggests that there will be a nearly endless variety of both mass-market and niche-market wireless applications if there is a band where these and other low-powered, user-oriented devices can operate on an unlicensed basis. An allocation of 40 MHz would clearly serve the public interest.

U S WEST urges, in this connection, that at least half of the 40 MHz be configured as a duplex pair of channels to permit frequency-division duplex ("FDD") operation. This is critical in order to provide for interoperability between licensed and

^{72/} See WINForum Comments at 2; Apple Computer, Inc. Comments at 2-3; AT&T Comments at 13; and Motorola Comments at 9.

^{73/} For example, six years ago U S WEST's subsidiary, U S WEST NewVector Group, Inc. filed comments in PR Docket 86-174 supporting the establishment of Radio Local Area Networks in the 1.7 GHz band. The comments supported blanket licensing of radio-based local networks that could be used for both computer communications and for other applications. NewVector suggested at that time that individual licensing of radio LAN users would be unduly burdensome. See NewVector Comments, PR Docket 86-174, at 9.

unlicensed systems.^{74/} For example, cordless telephones designed to operate in the duplex User-PCS could be designed to interface transparently with licensed PCS networks simply by shifting to a different frequency band, with no need for the complexity and expense of dual-mode operation. This will permit combined economies of scope and scale for licensed and unlicensed devices.

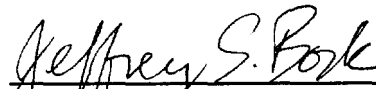
V. CONCLUSION

For the foregoing reasons, U S WEST respectfully suggests that the Commission adopt PCS regulations consistent with the suggestions contained herein as well as with the additional points in U S WEST's November 9, 1992 Comments that are not addressed herein.

Respectfully submitted,

U S WEST, INC.

By:


 Jeffrey S. Bork
 Keith G. Galitz

1020 19th Street, N.W.
 Suite 700
 Washington, D.C. 20036
 (202) 429-0303

Of Counsel

Laurie Bennett

January 8, 1993

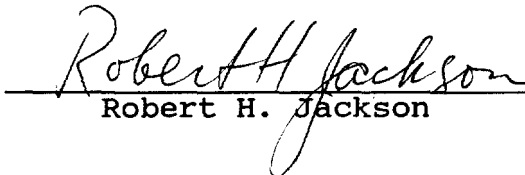
Its Attorneys

^{74/}

The spacing between the paired frequencies should clearly be the same as the spacing used for licensed PCS, in order to facilitate such interoperability. Moreover, unlicensed devices could use the same common air interface used for licensed services in order to promote interoperability. U S WEST takes this opportunity to reiterate its strong support for Commission adoption of technical standards, including a common air interface, based on the work of industry standards groups, and urges the Commission not to simply leave standards to the marketplace, which could retard standardization significantly.

CERTIFICATE OF SERVICE

I, Robert H. Jackson, hereby certify that on January 8, 1993, a copy of the foregoing "Reply Comments of U S WEST, Inc.," was served by United States first-class mail, postage prepaid, to the parties on the attached list.


Robert H. Jackson

John P. Bankson, Jr.
Joe D. Edge
Hopkins & Sutter
PCN America, Inc.
888 Sixteenth Street, N.W.
Washington, D.C. 20006

Jack T. Taylor
TSS Associates
6116 Brassie Way
Redding, CA 96003

Richard M. Stokes
Atlantic Electric
1199 Black Horse Pike
Pleasantville, NJ 08232

Michael Baly, III
President
American Gas Association
1515 Wilson Boulevard
Arlington, VA 22209

Robert G. Lott
DoveCo Communications
1929 Martindale Drive
Fayetteville, NC 28304

Lawrence J. Movshin
Thelen, Marrin,
Johnson & Bridges
IEEE Standards Project 802
805 15th Street, N.W.
Washington, D.C. 20005-2207

Colonel Socrates G. Lecakes
Deputy Superintendent
New York State Police
Public Security Building
State Campus
Albany, NY 12226

Honorable Thomas J. Bliley, Jr.
House of Representatives
2241 Rayburn House Office Bldg.
Washington, D.C. 20515-4603

Donald J. Helm
Washington Gas
1100 H Street, N.W.
Washington, D.C. 20080

Paul R. Kessler
New York Eye and Ear Infirmary
2nd Avenue at 14th Street
New York, NY 10003

Mark K. Roberts
Superintendent of Communications
SCADA, and Metering
Grand River Dam Authority
P. O. Box 409
Vinita, OK 74301-0409

George W. Toyne
General Manager
Corn Belt Power Cooperative
1300 Thirteenth Street
P. O. Box 508
Humboldt, Iowa 50548

Ronald C. Oakley
Manager - Telecommunications
Arkansas Power & Light Co.
425 West Capitol
Little Rock, AR 72203

James A. Vann, Jr.
Executive VP and
General Manager
Alabama Electric
Cooperative, Inc.
P. O. Box 550
Andalusia, AL 36420

John K. Davis
General Manager
Sho-Me Power Corporation
Marshfield, MO 65706

Michael P. Sercer
Communications Supervisor
Indianapolis Power & Light Co.
P. O. Box 1595
Indianapolis, IN 46206

Steve Slaughter
Engineering Manager
Guadalupe Valley Electric
Cooperative, Inc.
P. O. Box 118
Gonzales, TX 78629-0118

Richard McKenna HQE03J36
GTE Service Corporation
P. O. Box 152092
Irving, TX 75015-2092

W. Lester Bryan
VP - Power Supply
Washington Water Power
P. O. Box 3727
Spokane, WA 99220

Jackson H. Randolph
President and Chief
Executive Officer
Cincinnati Gas & Electric Co.
P. O. Box 960
Cincinnati, OH 45201-0960

Glen D. Churchill
President & Chief
Executive Officer
West Texas Utilities Co.
P. O. Box 841
Abilene, TX 79604

Harry D. Mattison
Executive Vice President &
Chief Operating Officer
Central and South West Corp.
P. O. Box 660164
Dallas, TX 75266-0164

Joseph W. Koch, Jr.
Manager
The Gas Company
P. O. Box 3249
Los Angeles, CA 90051-1249

Dennis L. Hill
Data Retrieval Manager
Northwest Iowa Power Cooperative
P. O. Box 240
Le Mars, Iowa 512031

Miles Walters
SC/DA Engineer
Dept. of Public Utilities
County of Los Alamos
P. O. Box 30
Los Alamos, NM 87544

Gene H. Kuhn
Director, Telecommunications
Transmission
Union Pacific Railroad Co.
Missouri Pacific Railroad Co.
1416 Dodge Street
Omaha, NE 68179

Ted V. Lennick
General Manager
Cooperative Power Association
14615 Lone Oak Road
Eden Prairie, MN 55344-2287

Mary M. Polfer
Vice President
Public Service
Company of Oklahoma
P. O. Box 201
Tulsa, OK 74102-0201

John A. Bohling
Executive Vice President
Pacific Power & Light Co.
920 S.W. Sixth Avenue
Portland, OR 97204

Ruben Morgan
Supervisor Relay & Communications
Electric T & D Division
City of Tallahassee
2602 Jackson Bluff Road
Tallahassee, FL 32304

Dale V. Fetchenhier
VP - Information and
Technology & Service
Public Service Co. of Colorado
P. O. Box 840
Denver, CO 80201-0840

Tom Moore
Director, System Operations
Western Farmers Electric Cooperative
P. O. Box 429
Anadarko, OK 73005

Melvyn Cobb
Manager, System Communications
Kentucky Utilities Company
One Quality Street
Lexington, KY 40507

Kevin M. Walsh, P.E.
Manager, Network Engineering
and Maintenance
Niagara Mohawk Power Corp.
300 Erie Boulevard West
Syracuse, NY 13202

Arthur K. Neill
Executive Vice President
Montana Power Company
40 East Broadway
Butte, MT 59701

Robert R. Carey
President and Chief
Executive Officer
Central Power and Light Co.
P. O. Box 2121
Corpus Christi, TX 78403

John W. Paylor
Director of Information Services
Southwestern Electric Power Co.
P. O. Box 21106
Shreveport, LA 71156-0001

Wayne C. Hamilton
Manager, Telecommunications Dept.
Carolina Power & Light Company
P. O. Box 1551
Raleigh, NC 27602

John L. Sokol, Jr., P.E.
Executive Director
Pennsylvania Turnpike Commission
Harrisburg, PA 171105

John L. Rafuse
Manager, Government Relations
Unocal
P. O. Box 7600
Los Angeles, CA 90051

David L. Rountree
Director of Engineering
Northeast Oklahoma Electric
P. O. Box 948
Vinita, OK 74301-0948

David B. Trego
Manager
Telecommunications Division
American Electric Power
Service Corporation
1 Riverside Plaza
Columbus, OH 43215

Warren K. Lotsberg
Vice President - Consumer Affairs
Northwestern Public Service Co.
P. O. Box 1318
Huron, SD 57350-1318

Bruce B. Samson
Northwest Natural Gas Co.
One Pacific Square
220 N.W. Second Avenue
Portland, OR 97209

William A. Merrill
Vice President - Operations
Nebraska Public Power District
P. O. Box 499
Columbus, NE 68602-0499

John C. Anderson
Executive Vice President
Southside Electric Cooperative
P. O. Box 7
Crewe, VA 23930

Ralph E. Shaw
General Manager
Northeast Missouri Electric
Power Cooperative
P. O. Box 191
Palmyra, MO 63461

Douglas W. Johnson
Executive Vice President
Blue Ridge Electric
Membership Corporation
Caller Service 112
Lenoir, NC 28645

Byron R. Bergman
Asst. Systems Engineering
Manager
Light Division
Tacoma Public Utilities
P. O. Box 11007
Tacoma, WA 98411

Louis Stroup, Jr.
Executive Director
Kansas Municipal
Utilities, Inc.
P. O. Box 1225
McPherson, KS 67460

Jerome J. Mistek
Manager, Communications
and Metering
Interstate Power Company
P. O. Box 769
Dubuque, Iowa 52004-0769

Tom W. Davidson
Mark D. Schneider
Clairtel Communications
Sidley & Austin
1722 Eye Street, N.W.
Washington, D.C. 20554

Daniel L. Bart
1850 M Street, N.W.
Suite 1200
Washington, D.C. 20036

Stuart Dolgin
Local Area Telecommunications
17 Battery Place, Suite 1200
New York, NY 10004-1256

Werner K. Hartenberger
Laura H. Phillips
Jonathan M. Levy
Dow, Lohnes & Albertson
1255 23rd Street, N.W.
Suite 500
Washington, D.C. 20037

John D. Lane
Robert M. Gurss
Wilkes, Artis, Hedrick & Lane
1666 K Street, N.W.
Suite 1100
Washington, D.C. 20006-2866

George Petrustas
Paul J. Feldman
Fletcher, Heald & Hildreth
1225 Connecticut Avenue, N.W.
Suite 400
Washington, D.C. 20036-2679

Scott K. Morris
Mark R. Hamilton
McCaw Cellular Communications, Inc.
5400 Carillon Point
Kirkland, WA 98033

Stephen P. Carrier
Hughes Network Systems, Inc.
11717 Exploration Lane
Germantown, MD 20874

John C. Carrington
Mercury Personal Communications
Network, Ltd.
1 Harbour Exchange Square
London E14 9GE, UK

David A. LaFuria
Lukas, McGowan, Nace
& Gutierrez
1819 H Street, N.W.
Seventh Floor
Washington, D.C. 20006

Marilyn M. Moore
Michigan Public Service Comm.
6545 Mercantile Way
P. O. Box 30221
Lansing, MI 48909

John E. Hoover
Jones, Day, Reavis & Pogue
1450 G Street, N.W.
Washington, D.C. 20005-2088

Tak Immamura
Mitsubishi Electric Corp.
1-1, Tsukaguchi - Honmachi
8-Chome
Amagasaki City, Kyogo 661, Japan

Stuart E. Overby
Michael D. Kennedy
Leonard S. Kolsky
Motorola Inc.
1350 I Street, N.W., Suite 400
Washington, D.C. 20005

David E. Weisman
Alan S. Tilles
Myer, Faller, Weisman
& Rosenberg, P.C.
4400 Jenifer Street, N.W.
Suite 380
Washington, D.C. 20015

Larry A. Blosser
Donald J. Elardo
MCI Telecommunications Corp.
1801 Pennsylvania Avenue, N.W.
Washington, D.C. 20006

William H. Talmage
NCR Corporation
1700 S. Patterson Blvd.
Dayton, OH 45479

Dr. Robert L. Riemer
Committee on Radio Frequencies
National Research Council
2101 Constitution Avenue
Washington, D.C. 20418

Penny Rubin
New York State Department
of Public Service
Three Empire State Plaza
Albany, NY 12223

James G. Ennis
Fletcher, Heald & Hildreth
1225 Connecticut Avenue, N.W.
Suite 400
Washington, D.C. 20036

Northern Telecom, Inc.
Albert Halprin
Werner, Lipfert, Bernnard,
McPherson and Hand
901 15th Street, N.W.
Washington, D.C. 20005

Charles T. Force
National Aeronautics and
Space Administration
Washington, D.C. 20546

Roland Williams
NovAtel Communications, Ltd.
1020 - 64 Avenue, N.E.
Calgary, Alberta, Canada
T2E 7V8

Henry L. Baumann
Barry D. Umansky
National Association
of Broadcasters
1771 N Street, N.W.
Washington, D.C. 20036

Dennis L. Hill
Northwest Iowa Power Cooperative
P. O. Box 240
Le Mars, Iowa 51031

Joseph P. Markoski
Squire, Sanders & Dempsey
1201 Pennsylvania Avenue, N.W.
P. O. Box 407
Washington, D.C. 20044

Robert M. Jackson
Richard D. Rubino
Blooston, Mordkofsky,
Jackson & Dickens
2120 L Street, N.W.
Suite 810
Washington, D.C. 20037

David Cosson
L. Marie Guillary
National Telephone
Cooperative Association
2626 Pennsylvania Ave., N.W.
Washington, D.C. 20037

Ericsson Corporation
David C. Jatlow
Young & Jatlow
2300 N Street, N.W.
Suite 600
Washington, D.C. 20037

David A. Hendon
Department of Trade
and Industry
Kingsgate House
56-74 Victoria Street
London SW1E 6SW England

Scott J. Loftesness
Fidelity Investments
82 Devonshire Street
Boston, MA 02019

Lawrence R. Krevor
Jones, Day, Reavis & Pogue
1450 G Street, N.W.
Washington, D.C. 20005

Jack T. Taylor
Digital Spread Spectrum
Technologies, Inc.
110 South Wolfe Road
Synnyvale, CA 94086

William L. Fishman
Sullivan & Worcester
1035 Connecticut Avenue, N.W.
Washington, D.C. 20036

James A. Dwyer, Jr.
2100 Electronics Lane
Fort Myers, FL 33912

Andrew D. Lipman
Catherine Wang
Margaret M. Charles
Shelley L. Spencer
Swidler & Berlin
3000 K Street, N.W., Suite 300
Washington, D.C. 20007

George J. Brennan
Mirijana Kocho
Mary McDermott
Patrick J. O'Shea
NYNEX Corporation
120 Bloomingdale Road
White Plains, NY 10605

Robert A. Mazer
Veronica M. Ahern
Nixon, Hargrave,
Devans & Doyle
One Thomas Circle, N.W.
Suite 800
Washington, D.C. 20005

Lisa M. Zaina
OPASTCO
2000 K Street
Suite 205
Washington, D.C. 20005

Peter Tannenwald
Arent, Fox, Kintner,
Plotkin & Kahn
1050 Connecticut Avenue, N.W.
Washington, D.C. 20036-5539

Nancy J. Thompson
Reed, Smith Shaw & McClay
1200 18th Street, N.W.
Washington, D.C. 20036

Paul R. Zielinski
Rochester Telephone Corp.
180 South Clinton Avenue
Rochester, NY 14646-0700

Thomas E. Martinson
Vice President
PCN America, Inc.
153 East 53rd
Suite 2500
New York, NY 10022

M. John Bowen, Jr.
John W. Hunter
McNair Law Firm, P.A.
1155 Fifteenth Street, N.W.
Washington, D.C. 20005

Michael S. Slomin
Bell Communications Research, Inc.
290 W. Mt. Pleasant Avenue
Livingston, NJ 07039

Elizabeth F. Maxfield
Michael F. Altschul
Cellular Telecommunications
Industry Association
1133 21st Street, N.W.
Suite 300
Washington, D.C. 20036

Paul R. Rodriguez
Leventhal, Senter & Lerman
2000 K Street, N.W.
Suite 600
Washington, D.C. 20006-1809

William D. Baskett, III
Thomas E. Taylor
James F. Lummanick
Frost & Jacobs
2500 Central Trust Center
201 East Fifth Street
Cincinnati, OH 45202

Lynn Diebold
California Public Safety
Radio Association
4016 Rosewood Avenue
Los Angeles, CA 90004

William J. Cole
Cobra Electronics Group of
Dynascan Corporation
6500 West Cortland Street
Chicago, IL 60635

Kenneth J. Brown
Capital Cities/ABC, Inc.
77 West 66th Street
New York, NY 10023

Linda T. Muir
Contel Corporation
245 Perimeter Center Pkwy.
Atlanta, GA 30346

F. G. Harrison
Cellnet
Hanover House
49-60 Borough Road
London SE1 1DS
England

R. Michael Senkowski
Richard E. Wiley
David E. Hilliard
Eric W. DeSilva
Wiley, Rein & Fielding
1776 K Street, N.W.
Washington, D.C. 20006

Wayne V. Black
Keller and Heckman
1150 17th Street, N.W.
Suite 1000
Washington, D.C. 20036

Dr. Michael Trahos
4600 King Street
Suite 4E
Alexandria, VA 22302

Pete Wanzenried
State of California
Telecommunications Division
601 Sequoia Pacific Blvd.
Sacramento, CA 95814-0282

Paul Taft
Taft Broadcasting Company
4808 San Felipe Road
Houston, TX 77056

William D. Balthrope
Texas Wired Music, Inc.
P. O. Box 8278
San Antonio, TX 78208

Mohamed Lyzzaik
United Power
P. O. Box 929
Brighton, CO 80601

John W. Pettit
Hopkins & Sutter
888 Sixteenth Street, N.W.
Suite 700
Washington, D.C. 20006

Gene H. Kuhn
Union Pacific Railroad Co.
Missouri Pacific Railroad Co.
1416 Dodge Street
Omaha, NE 68179

Alan Y. Naftalin
Margot Smiley Humphrey
George Y. Wheeler
Koteen & Naftalin
1150 Connecticut Avenue, N.W.
Suite 1000
Washington, D.C. 20036

William J. Cole
Telecommunications Industry
Association
2001 Pennsylvania Avenue, N.W.
Suite 800
Washington, D.C. 20006-1813

Eric J. Schimmel
Telecommunications Industry
Association
2001 Pennsylvania Avenue, N.W.
Suite 800
Washington, D.C. 20006-1813

Christopher D. Imlay
Booth, Freret & Imlay
1920 N Street, N.W.
Suite 150
Washington, D.C. 20036

Marci E. Greenstein
Lukas, McGowan, Nace
& Gutierrez
1819 H Street, N.W.
7th Floor
Washington, D.C. 20006

Russell H. Fox
American SMR Network Assoc.
1835 K Street, N.W.
Suite 203
Washington, D.C. 20006

Bruce D. Jacobs
Glenn S. Richards
Gregory L. Masters
Fisher, Wayland,
Cooper & Leader
1255 23rd St., N.W., Suite 800
Washington, D.C. 20037

Francine J. Berry
David P. Condit
Peter H. Jacoby
Sandra Williams Smith
American Telephone &
Telegraph Co.
295 North Maple Avenue
Basking Ridge, NJ 07920

Glenn S. Richards
Gruman, Kurtis, Blask
& Freedman, Chartered
1400 Sixteenth Street, N.W.
Suite 500
Washington, D.C. 20036

Robert N. Reiland
Ameritech
30 South Wacker Drive
Suite 3900
Chicago, IL 60606

Jonathan D. Blake
Kurt A. Winner
Ellen K. Snyder
Nancy Ann E. Min
Covington & Burling
P. O. Box 7566
1201 Pennsylvania Avenue, N.W.
Washington, D.C. 20044

James F. Lovette
Apple Computer, Inc.
20525 Mariani Avenue, Ms46A
Cupertino, CA 95014

Robert E. Tall
Associated Public-Safety
Communications Officers
2040 S. Ridgewood Ave., #100
Daytona Beach, FL 32119-2257

Margaret deB. Brown
Pacific Telesis Group
130 Kearny Street
Room 3659
San Francisco, CA 94108

James L. Wurtz
Pacific Telesis Group
1275 Pennsylvania Avenue, N.W.
4th Floor
Washington, D.C. 20004

Robert J. Jackson
Harold Mordkofsky
Blooston, Mordkofsky,
Jackson & Dickens
2120 L Street, N.W.
Suite 300
Washington, D.C. 20037

James E. McNulty
President & CEO
Rose Communications Inc.
2390 Walsh Avenue
Santa Clara, CA 95051